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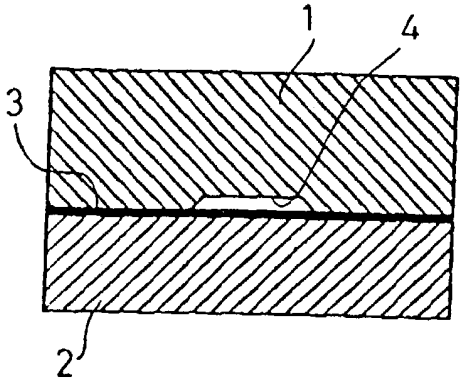
(57) Abstract

In a method of forming a microchannel and/or microcavity structure by bonding together two elements (1, 2) having opposed plane surfaces of the same or different materials, one or both surfaces having open channels and/or cavities, bonding is effected by applying to one or both element surfaces (1, 2) a thin layer (3) of a solution of a material capable of fusing with and having a lower melting point than that of the material or materials of the two element surfaces (1, 2) in a solvent which substantially does not dissolve the element surface material or materials. The solvent is then removed, and the two elements (1, 2) are brought together and heated to a temperature where the dissolved material is caused to melt but not the element surface material or materials.



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METHOD OF PRODUCING MICROCHANNEL/MICROCAVITY STRUCTURES

The present invention relates to the production of microchannel and microcavity systems, and more particularly to an improved method of bonding plane layers together in such production.

Microchannel or microcavity structures are used in inter alia chemical analytical techniques, such as electrophoresis and chromatography. In one type of such microfluidic structures, a channel and/or cavity system is defined between two plane material layers, the recesses which correspond to the channels and cavities, respectively, being formed in one or both of the opposed layer surfaces. The layers are usually bonded together by gluing. Alternatively, if the two layers consist of thermoplastic material, they may be fused together by the application of heat.

When very small channel dimensions are concerned, however, these conventional joining methods tend to deform the channel or cavity system to a great extent by partial clogging with glue or molten material.

The object of the present invention is to overcome this problem by providing a method which permits convenient bonding together of the material layers substantially without affecting the channel or cavity system.

According to the invention, this is achieved by a method of production which has the features defined in claim 1. Preferred embodiments are defined in the subclaims.

The invention is based on the concept that in order to bond together two planar element surfaces of the same or different materials, preferably thermoplastic, which surfaces when brought together define a channel and/or cavity system between them, there is applied to one or, preferably, both element surfaces a thin layer of another, preferably also thermoplastic, material dissolved in a solvent which does not dissolve the material of the two element surfaces. This dissolved material should, on one

hand, be capable of being fused with the material(s) of the two surfaces on which it has been coated, and, on the other hand, melt at a lower temperature than the melting temperature of the element surface material or materials. After evaporation of the solvent, the two surfaces are brought together, e.g. by rolling, whereupon the assembly is heated to a temperature that melts the intermediate (preferably thermoplastic) material but not the material of the element surfaces for effecting joining of the two element surfaces.

The applied solution layer should, of course, have a very small thickness in relation to the width and depth of the channels and microcavities, respectively, which width and depth may be of the order of magnitude of 50 to 100 μm, for example.

When a thermoplastic material is used for the two material surfaces, this thermoplastic material is suitably closely related to the thermoplastic material responsible for the bonding of the channel/cavity structure. As an example of a suitable type of thermoplastic for the present purpose may be mentioned fluoroelastomers.

Suitable combinations of surface/bonding materials and solvents for practising the invention will readily be devised by the person skilled in the art guided by the present description.

The carrying out of the process of the invention is illustrated schematically in the accompanying drawings, wherein Figs. 1A to 1C show different substeps in the manufacture of a microfluidic structure, and Fig. 2 is a cross-section of the final product.

Fig. 1A shows a plate 1 provided with an open channel system (not shown), which plate together with an identical plate 2 without the channel system is intended to define a microchannel system between the two plates. For bonding the two plates together, which preferably are made of a thermoplastic material, e.g. a fluoroelastomer, a thin layer 3 of a, preferably closely related, thermoplastic material, e.g. a modified fluoroelastomer with a lower

melting point, is first spun onto both plate surfaces. Then the solvent is baked off at an increased temperature (e.g. 135 °C), as is illustrated in Fig. 1B. The two plates treated in this way are then rolled together, as indicated in Fig. 1C, and are allowed to be bonded together for some time, e.g. 5 minutes. The completed microchannel structure is shown in Fig. 2. As may be seen from the latter figure, the two plates 1, 2, which are held together by the material layer 3, define a channel system 4 between them.

The following specific Example, which describes the production of a microchannel structure, illustrates the method of the invention further.

EXAMPLE

A polymer structure with closed straight channels having a height of 50 μm, a width of 250 μm and a length of about 80 mm was produced in the following manner.

A silicon mould having a surface relief structure corresponding to the desired channel geometry was manufactured in per se known manner. Thus, the surface of a silicon plate was first oxidized at about 1100 °C to form an oxide layer of 8000 Å thickness. After washing, dehydration in an oven and priming with hexamethylsilane, a photoresist layer was spun onto the oxide layer and was stabilized by baking in an oven. A mask corresponding to the desired channel pattern was then placed on the plate surface, and the surface parts not covered by the mask were exposed to light. The exposed photoresist parts were then removed by developing solution to bare the oxide layer, and the remaining photoresist was hard-baked. The bared oxide was then etched with hydrofluoric acid/ammonium fluoride to expose the silicon (the backside of the plate being protected by resistant tape), whereupon the photoresist mask was removed by acetone. The oxide-free silicon surfaces were then etched with potassium hydroxide solution for a sufficient time to produce the desired etch depth. The resulting surface exhibited the desired channel pattern.

The silicon mould obtained was then pressed against a 2 mm thick film of Hostaflon TFB 7100 (refractive index about 1.36) at about 160 °C and 20 kp/cm^2. (Hostaflon is a thermoplastic fluoroelastomer sold by Hoechst AG, Germany). The resulting channel structure was bonded to a base layer in the form of a plane plate of the same material by spinning a thin layer of Hostaflon TFB X-7200 (having a lower melting point than that of Hostaflon TFB 7100) dissolved in propylmethylketone onto the base layer and the channel structure, which were then allowed to dry at 130 °C for 10 minutes. The channel structure and the base layer were then immediately rolled together, and the obtained sandwich was baked at about 140 °C for 10 minutes. The polymer structure produced in this way exhibited intact closed channels.

The invention is, of course, not restricted to the embodiment described above and specifically shown in the drawing, but many modifications and changes may be made within the scope of the general inventive concept as it is stated in the following claims.

CLAIMS

1. A method of forming a microchannel and/or microcavity structure by bonding together two elements (1, 2) having opposed plane surfaces of the same or different materials, one or both surfaces having open channels and/or cavities, **characterized** in that said bonding is effected by applying to one or both element surfaces (1, 2) a thin layer (3) of a solution of a material capable of fusing with and having a lower melting point than that of the material or materials of the two element surfaces (1, 2) in a solvent which substantially does not dissolve the element surface material or materials, removing the solvent, bringing the two elements (1, 2) together, and heating to a temperature where the dissolved material is caused to melt but not the element surface material or materials.

2. The method according to claim 1, **characterized** in that the two elements (1, 2) that are to be bonded together are of the same material.

3. The method according to claim 1 or 2, **characterized** in that the dissolved material (3) is thermoplastic.

4. The method according to any one of claims 1 - 3, **characterized** in that the material of the two elements (1, 2) is thermoplastic.

5. The method according to claim 4, **characterized** in that the material of the two elements (1, 2) and the dissolved material (3) are of substantially the same type.

6. The method according to claim 5, **characterized** in that the materials of the two elements (1, 2) and the dissolved material (3) are fluoroelastomers.

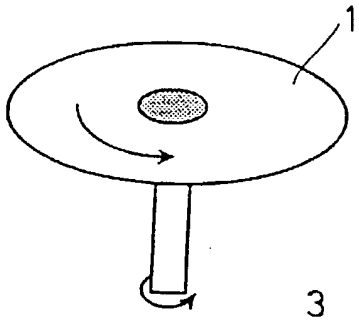

FIG. 1A

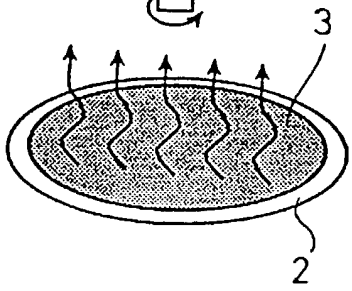

FIG. 1B

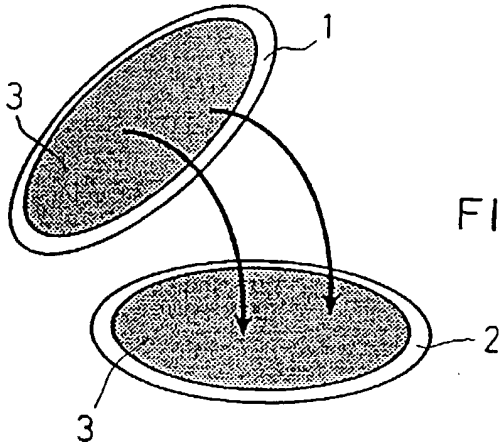

FIG. 1C

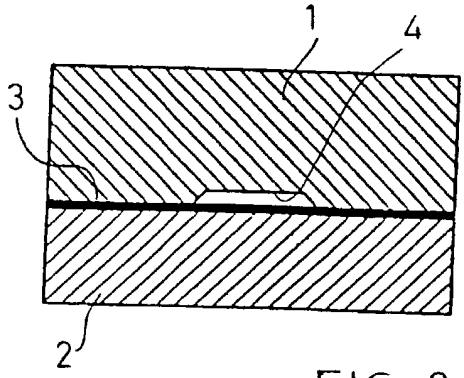

FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 94/00584

A. CLASSIFICATION OF SUBJECT MATTER

IPC5: C09J 5/06, G01N 30/60
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC5: C09J, G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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EPODOC, PAJ, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE, A1, 4128964 (FOTOCHEMISCHE WERKE GMBH), 4 March 1993 (04.03.93) -- --------	1-5

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE-A1- 4128964	04/03/93	NONE	